

Additions to the graminicolous rust fungi of Pakistan

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Abstract — *Puccinia khanspurica* is described as a new species, with *P. crandallii* and *P. virgata* as new records for Pakistan.

Key words — Khanspur, Nathia Gali, *Poaceae*, *Pucciniales*, *Sorghum halepense*

Introduction

Puccinia Pers. is the largest genus of *Pucciniales*, with about 3000–4000 species. Species of *Asteraceae*, *Cyperaceae*, *Poaceae*, and *Liliaceae* are hosts for large numbers of species, but numerous other species of *Puccinia* infect plant species of most other groups of vascular plants (Perdomo-Sánchez & Piepenbring 2008). Most members of *Poaceae* are favorable hosts for *Puccinia* and about 650 species of this genus occur on graminaceous hosts worldwide (Afshan et al. 2008a).

Until to 1997, forty-six species of *Puccinia* were known from Pakistan on different members of *Poaceae* (Ahmad et al. 1997). Based on recent work for the enumeration of the graminicolous rust fungi from Pakistan, sixty species of *Puccinia* are now known on graminaceous hosts from this country (Afshan et al. 2007, Afshan & Khalid 2008, Afshan et al. 2008a, b, c, Iqbal et al. 2008).

In the present investigation, three species of *Puccinia* were found infecting three members of *Poaceae*. Among these, *Puccinia khanspurica* on *Sorghum halepense* is new to science. *P. crandallii* on *Poa tibetica* and *P. virgata* on *Panicum antidotale* are additions to the rust fungi of Pakistan.

Materials and methods

Freehand sections of infected tissue and spores were mounted in lactophenol and gently heated to boiling. The preparations were observed under a NIKON YS 100 microscope and photographed with a digipro-Labomed. Drawings of spores and paraphyses were made using a Camera Lucida (Ernst Leitz Wetzlar, Germany). Spore dimensions were taken using an ocular micrometer. At least

25 spores were measured for each spore stage. The rusted specimens have been deposited in the herbarium of the Botany Department, University of the Punjab, Lahore (LAH).

Enumeration of taxa

Puccinia khanspurica Khalid & Afshan, sp. nov.

(FIGS. A–B, TABLE 1)

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Spermogonia et *aecia* ignota. *Uredinia* amphigena, brunnea, striiformia. *Urediniosporae* globosae, ovoideae vel ellipsoideae; $19\text{--}25 \times 21\text{--}29\ \mu\text{m}$; membrana $1.5\text{--}2\ \mu\text{m}$ crassa, pallidae-brunneae, delicate vel striolatae verrucosae; poris germinationis 2–4, aequatorialibus, pedicellis hyalinis, usque ad $15\ \mu\text{m}$ longis. *Paraphysibus* clavatis vel capitatis, brunneae, basaliter hyalinae vel pallidae-brunneae, apice $10\text{--}17\ \mu\text{m}$ crasso, basaliter $5\text{--}8\ \mu\text{m}$ crasso, membrana $3\text{--}4\ \mu\text{m}$ crasso, usque ad $95\ \mu\text{m}$ longo. *Telia* amphigena, subepidermalia, atra, striiformia. *Teliosporae* 1–4 cellulares, clavatae, ellipsoideae vel cylindricae; $14\text{--}24\text{--}(26) \times (42\text{--})56\text{--}66\text{--}(74)\ \mu\text{m}$, membrana $1.5\text{--}2.5\ \mu\text{m}$ crassa, apicaliter brunneae vel cinnamomea-brunneae, basaliter pallidae, pariete levi; apice truncato vel rotundatis; pedicello brunneo, usque ad $6\text{--}7 \times 9\text{--}11\ \mu\text{m}$; *paraphysibus* brunneae, clavatae, usque ad $50\ \mu\text{m}$ longis.

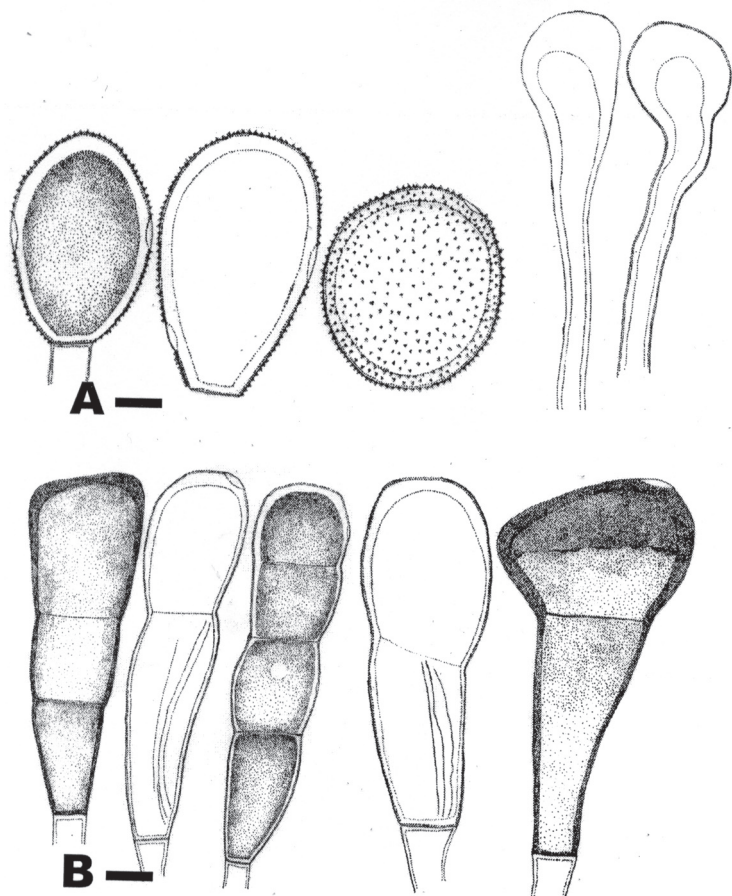
HOLOTYPE: On *Sorghum halepense* (L.) Pers., with II & III stages, Pakistan, North Western Frontier Province (NWFP), Khanspur, Helipad, at 2575 m a. s. l., 23rd May, 2006. NSA # 37. (LAH Herbarium No. NSA 1061).

ETYMOLOGY: Named after the locality, Khanspur.

SPERMOGONIA and **AECIA** unknown. **UREDINIA** amphigenous, $0.09\text{--}0.2 \times 0.2\text{--}0.4$ mm, golden brown, solitary or sometimes in linear rows. **UREDINIOSPORES** globose or ovoid to ellipsoid, $(19\text{--})21\text{--}25 \times 21\text{--}29\ \mu\text{m}$; wall $1.5\text{--}2\ \mu\text{m}$ thick, pale brown to golden brown, finely verrucose or striolate verrucose; germ pores 2–4, equatorial; pedicel hyaline, short, up to $15\ \mu\text{m}$ long. **PARAPHYSES** numerous, clavate to capitate, golden brown, but hyaline to pale brown basally, apex $10\text{--}17\ \mu\text{m}$ thick, $5\text{--}8\ \mu\text{m}$ thick at base, wall $3\text{--}4\ \mu\text{m}$ at sides while $6\text{--}11\ \mu\text{m}$ at apex, up to $95\ \mu\text{m}$ long. **TELIA** mostly amphigenous, black, striated, subepidermal, $0.09\text{--}0.1 \times 0.1\text{--}0.3$ mm. **TELIOPORES** 1–4-celled, mostly 2-celled, papery, clavate or ellipsoid to broadly ellipsoid or mostly cylindrical, $14\text{--}24\text{--}(26) \times (42\text{--})56\text{--}66\text{--}(74)\ \mu\text{m}$; wall $1.5\text{--}2.5\ \mu\text{m}$ thick, golden brown to cinnamon brown apically, pale brown basally, smooth; apex mostly truncate, sometimes rounded, $4\text{--}12\ \mu\text{m}$ thick; germ pore 1 per cell; pedicel short, brown, $6\text{--}7 \times 9\text{--}11\ \mu\text{m}$. **PARAPHYSES** brown, few, clavate, surrounding the sori, $4\text{--}6 \times 47\text{--}50\ \mu\text{m}$.

COMMENTS: Rust fungi reported on *Sorghum* spp. include *P. levis* var. *panici-sanguinalis* (Rangel) Ramachar & Cummins, *P. nakanishikii* Dietel, *P. purpurea* Cooke and *Uredo geniculata* Cummins (Cummins 1971).

Puccinia khanspurica is characterized by the presence of 1–4-celled teliospores with shorter pedicels. Moreover, the presence of thicker apices of teliospores with papery, clavate or ellipsoid to broadly ellipsoid or mostly cylindrical shape makes it different from other *Puccinia* species reported on



FIGS. A–B: Lucida drawings of *Puccinia khanspurica* (holotype).

A. Echinulated urediniospores with capitate paraphyses;

B. 2–4-celled teliospores.

Scale bar = 10 μ m.

the same host or the same tribe. (A comparison of *P. khanspurica* with similar species is presented in Table 1)

Puccinia purpurea resembles *P. khanspurica* in having subepidermal telia, smooth teliospores and clavate to capitate uredinial paraphyses. However, *P. khanspurica* is different by smaller urediniospores and thin, longer teliospores. In addition, number and distribution of germ pores and wall ornamentation of urediniospores are different in the *P. khanspurica* and *P. purpurea*.

P. khanspurica has few characters similar to *P. nakanishikii* including the presence of clavate to capitate paraphyses and smooth teliospores. But it can

TABLE 1. Comparison of *Puccinia khanspurica* with similar *Puccinia* spp.

<i>PUCCINIA</i> <i>KHANSPURICA</i>	<i>PUCCINIA</i> <i>PURPUREA</i>	<i>PUCCINIA</i> <i>NAKANISHIKII</i>	<i>PUCCINIA</i> <i>PYGMAEA</i>	<i>PUCCINIA</i> <i>RECONDITA</i>	<i>PUCCINIA</i> <i>POARUM</i>
UREDINIA					
amphigenous, subepidermal	abaxial, pulverulent	amphigenous or abaxial	unknown	often amphigenous	adaxial
UREDINIOSPORES					
globose or ovoid to ellipsoid	ellipsoid, obovoid, nearly globoid, often angular	oval or obovoid	ellipsoid, broadly ellipsoid or obovoid	broadly ellipsoid or obovoid	obovoid or ellipsoid
pale brown to golden brown	cinnamon brown to dark brown	dark cinnamon brown to chestnut brown	yellow to cinnamon brown	yellowish brown to cinnamon brown	colorless or pale yellow
finely verrucose or striolate	echinulate	echinulate	finely echinulate	echinulate	echinulate
GERM PORES					
2-4, equatorial	5-8, scattered, tending to be bizonate	4-5, equatorial	6-10, scattered, obscure	6-10, scattered	4-8, scattered
SIZE					
21-25 × 21-29 µm	23-32 × 26-40 µm	17-26 × 26-38 µm	18-26 × 24-35 µm	17-28 × 20-36µm	14-26 × 21-37 µm
PARAPHYSES					
clavate to capitate, golden brown, numerous	clavate-capitate, hyaline to yellowish	clavate-capitate, yellow to golden	capitate or clavate-capitate	unknown	capitate, short, few
TELIOPORES					
amphigenous, subepidermal, loculate	compact, pulvinate, exposed	compact, early exposed	abaxial, subepidermal	abaxial or adaxial, subepidermal	abaxial, subepidermal
1-4-celled, mostly 2-celled	2-celled	2-celled	2-celled	2-celled	2-celled
clavate, ellipsoid, broadly ellipsoid, or mostly cylindrical	ellipsoid or oblong-ellipsoid	mostly ellipsoid	oblong-obovoid or oblong	oblong-clavate	elongately obovoid or oblong-clavate
golden brown-cinnamon brown, paler basally	chestnut brown	chestnut brown	unknown	chestnut brown	chestnut brown above, golden basally
14-24 × 56-66 µm	22-33 × 37-55 µm	16-28 × 29-48 µm	14-26 × 32-58 µm	12-25 × 32-75µm	14-28 × 36-77 µm
APEX					
4-12 µm thick	4-7 µm thick	4-8 µm thick	2-6 µm thick	3-7 µm	2-8 µm
PEDICEL					
brown, 6-7 × 9-11 µm long	hyaline to yellow, ≤ 95 µm long	brown, collapsing, ≤ 65 µm long	yellow, ≤ 15 µm long	brown, ≤ 20 µm long	colorless or yellow, ≤ 15 µm long

be separated from the *P. nakanishikii* on the basis of 2–4-celled teliospores with thicker apices and finely verrucose or striolate verrucose urediniospores. *Puccinia nakanishikii* has only 2-celled teliospores with thinner apices and echinulate urediniospores. Other features that separate the two species are larger urediniospores and teliospores of the *P. khanspurica*.

Puccinia khanspurica can be separated from *P. pygmaea* Erikss. by the size of spores. *P. khanspurica* has smaller urediniospores and longer teliospores than *P. pygmaea*. Other differences are the presence of finely verrucose or striolate verrucose urediniospores with up to 4 equatorial germ pores and 1–4-celled teliospores in the *P. khanspurica* in contrast to *P. pygmaea* that has echinulated urediniospores with 6–10 scattered germ pores and only 2-celled teliospores.

Puccinia recondita Dietel & Holw. can be separated by the size and wall ornamentation of urediniospores which are smaller in *P. khanspurica* than in *P. recondita*. In addition, *P. recondita* possesses 6–10, scattered germ pores in the urediniospores and only 2-celled teliospores.

Puccinia khanspurica has some resemblance with *P. poarum* E. Nielsen by the size of teliospores. But it can be separated by the presence of 1-celled teliospores and size of urediniospores that are shorter in *P. khanspurica*. Other differences are the presence of finely verrucose or striolate verrucose urediniospores with 2–4, equatorial germ pores in *P. khanspurica* than in *P. poarum*.

Puccinia crandallii Pammel & H.H. Hume,

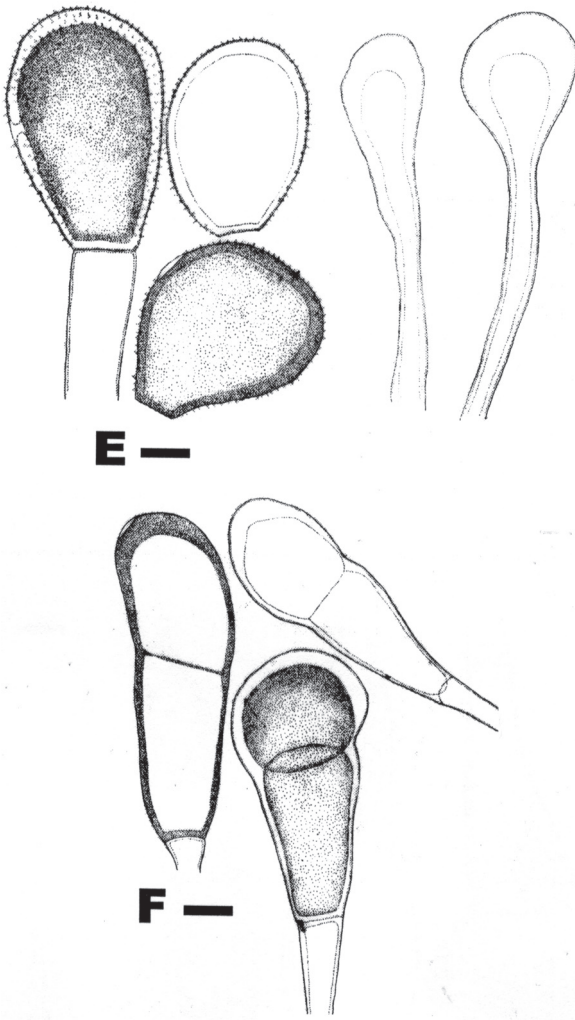
in Hume, Proc. Davenport Acad. Nat. Sci. 7: 250 (1899)

(Figs. C–D)

SPERMOGONIA and AECIA not found. UREDINIA amphigenous, subepidermal, light brown to golden brown, $0.09\text{--}0.1 \times 0.1\text{--}2.0$ mm. UREDINIOSPORES ovoid to obovoid or ellipsoid, $(12\text{--})19\text{--}22 \times 17\text{--}26(30)$ μm ; wall $1\text{--}1.5$ μm thick, pale brown to cinnamon brown, echinulate; germ pores 5–7, scattered, obscure; pedicel hyaline, $5\text{--}6$ μm wide and up to 35 μm long. TELIA amphigenous, covered by the epidermis, early exposed, dark brown to blackish brown, $0.09\text{--}0.5 \times 0.2\text{--}0.8$ mm. TELIOSPORES oblong to ellipsoid or narrowly obovoid, $1\text{--}3$ -celled, $(12\text{--})14\text{--}21(25) \times (29\text{--})32\text{--}47$ μm ; wall $1.5\text{--}2$ μm thick, cinnamon brown to chestnut brown but paler basally, smooth; apex truncate to rounded or conical, $4\text{--}8(10)$ μm thick; germ pore 1 per cell, obscure; pedicel hyaline to light brown, $4\text{--}8 \times 15\text{--}32(50)$ μm .

MATERIAL EXAMINED: On *Poa tibetica* Munro ex Stapf, with II and III stages, Pakistan, North West Frontier Province (NWFP), Nathia Gali, at 2545 m a. s. l., 12th October, 2007. NSA # B12. (LAH Herbarium No. NSA 1049).

COMMENTS: From Pakistan, *Puccinia brachypodii* var. *poae-nemoralis* (G. H. Otth) Cummins & H. C. Greene and *P. poarum* have previously been reported on *Poa annua*, *P. nemoralis*, *P. pratensis* and *P. sterilis* from Lahore, Sharan, Swat



FIGS. C–D: Lucida drawings of *Puccinia crandallii*.
C. Echinulated urediniospores. D. Teliospores.
Scale bar = 10 μ m.

and AJK by Ahmad (1956a, b), Kakishima et al. (1993a, b) and Masood et al. (1995).

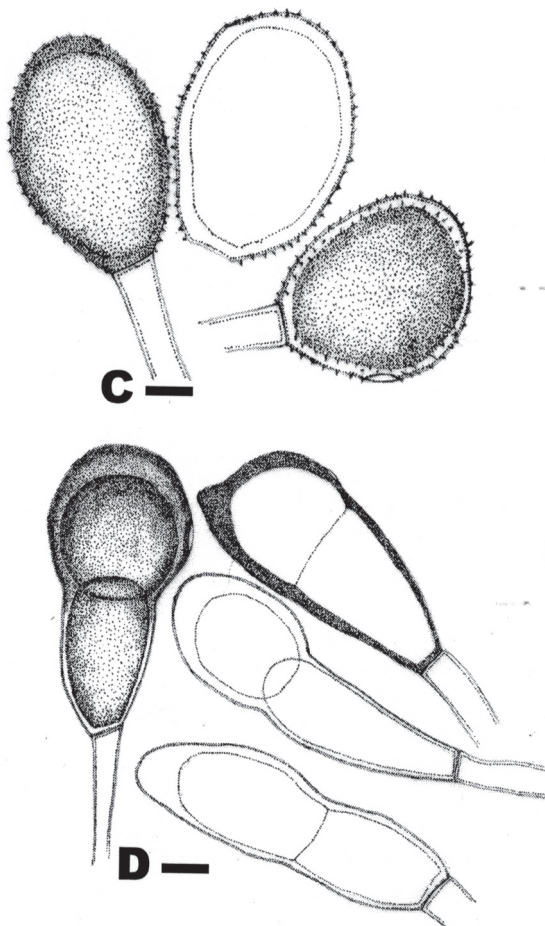
P. crandallii has previously been reported on species of *Poa* and *Festuca kingii* from the western United States (Cummins 1971). This rust is a new record for Pakistan and *Poa tibetica* is a new host for rust fungi of Pakistan.

Puccinia virgata Ellis & Everh.,

Proc. Acad. Nat. Sci. Philadelphia 1893: 154 (1893)

(FIGS. E-F)

SPERMOGONIA and AECIA unknown. UREDINIA intermixed with telia, subepidermal, light brown to golden brown, $0.07-0.2 \times 0.1-0.4$ mm. UREDINIOSPORES ovoid to obovoid or ellipsoid to broadly ellipsoid, $21-28 \times 26-36(-42)$ μm (mean 23.94×32.52 μm); wall $2-3$ μm thick, light brown to dark brown, echinulate; apex up to 4 μm thick, germ pores $2-4$, equatorial, pedicel



FIGS. E-F: Lucida drawings of *Puccinia virgata*.
 E. Urediniospores and paraphyses; F. Teliospores.
 Scale bar = 10 μm .

hyaline, 7–9 μm wide and up to 35 μm long. PARAPHYSES cinnamon brown to chestnut brown, capitate, apex 14–17 μm wide, 7–9 μm thick at lower side, wall of apex up to 4 μm wide, up to 75 μm long. TELIA amphigenous, subepidermal, dark brown to blackish brown, $0.1\text{--}0.5 \times 0.2\text{--}0.5$ mm. TELIOSPORES clavate or ellipsoid, constricted at septa, upper cell rounded, lower cell elliptical; wall 1.5–2 μm thick, apex chestnut brown but paler basally, smooth; $16\text{--}24 \times 37\text{--}54$ μm (mean 19.75×45.98 μm); apex mostly rounded to slightly conical, 3–5 μm thick; germ pore 1 per cell, obscure; pedicel light brown to cinnamon brown, $8\text{--}9 \times 14\text{--}18$ μm .

MATERIAL EXAMINED: On *Panicum antidotale* Retz., with II and III stages, Pakistan, North West Frontier Province (NWFP), Bara Gali, at 2407 m a. s. l., 12th October, 2007. NSA # B15. (LAH Herbarium No. NSA 1101).

COMMENTS: Previously, *Uromyces superfluous* P. Syd. & Syd. has been reported on *Panicum antidotale* from Changa Manga and Karachi by Ahmad (1956a, b), Hasnain et al. (1959) and Ghaffar & Kafi (1968). This rust has been reported on species of *Erianthus* and *Sorghastrum* from United States to Mexico and Brazil (Cummins 1971). *Puccinia virgata* is a new record for Pakistan.

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